

WHAT IS CLAIMED IS:

1. An evaluation method that evaluates regularity and degree of a nonlinear distortion of a substrate, comprising:

5 obtaining, for a plurality of divided areas on a substrate, position deviation amounts relative to predetermined reference positions by detecting respective marks, which are provided corresponding to said plurality of divided areas; and

10 evaluating regularity and degree of a nonlinear distortion of said substrate by using an evaluation function that is used to obtain correlation, concerning at least direction, between a first vector representing said position deviation amount of a given divided area on
15 said substrate and second vectors each of which represents said position deviation amount of a divided area of a plurality of divided areas around said given divided area.

20 2. An evaluation method according to claim 1, wherein said evaluation function is a function that is used to obtain correlation, concerning direction and size, between said first vector and said second vectors.

25 3. An evaluation method according to claim 1, wherein in addition, by using said evaluation function, a correction value of a piece of position information used to align each of said divided areas with respect to a

predetermined point is determined.

4. An evaluation method according to claim 1,
wherein said evaluation function is a second function
5 that represents an average of first N functions each of
which is used to obtain correlation, concerning at least
direction, between said first vector obtained by
selecting a respective divided area of N divided areas on
said substrate and said second vectors each of which
10 represents said position deviation amount of a divided
area of a plurality of divide areas around said
respective divided area of said N divided areas, N being
a natural number.

15 5. A position detection method that detects pieces
of position information to be used to align each of a
plurality of divided areas on a substrate with respect to
a predetermined point, said method comprising:

calculating said piece of position information
20 through use of a statistic computation using measured
position information obtained by detecting said plurality
of marks on said substrate; and

determining, for said piece of position information,
at least one of a correction value and a correction
25 parameter that determines said correction value, by using
a function that is used to obtain correlation, concerning
at least direction, between a first vector representing a
position deviation amount of a given divided area on said

substrate and second vectors each of which represents a position deviation amount of a divided area of a plurality of divide areas around said given divided area, said position deviation amount of said first vector being
5 relative to a predetermined reference position, said position deviation amounts of said second vectors being relative to respective predetermined reference positions.

6. A position detection method according to claim 5,
10 wherein, through said statistic computation, said pieces of position information having a linear component of a position deviation amount thereof corrected are calculated for said plurality of divided areas, and wherein at least one of said correction value and said
15 correction parameter is determined by using said function so that a nonlinear component of said position deviation amount is corrected.

7. A position detection method according to claim 5,
20 wherein said measured position information is in accord with position deviations of said divided areas relative to said predetermined point specified in design-position information, and wherein by performing a statistic computation using said measured position information
25 obtained from measuring at least three specific divided areas of said plurality of divided areas on said substrate, parameters of a conversion equation that calculates said pieces of position information are

obtained.

8. A position detection method according to claim 7,
wherein parameters of said conversion equation are
5 calculated with said measured position information being
weighted with an amount for each of said specific divided
areas, and wherein said weighting amount is determined by
using said function.

10 9. A position detection method according to claim 5,
wherein said measured position information contains
coordinates of said marks in a stationary coordinate
system defining movement position of said substrate, and
wherein said pieces of position information are
15 coordinates of said divided areas in said stationary
coordinate system.

10. A position detection method according to claim
5, wherein said correction values of said pieces of
20 position information are determined based on a complement
function optimized using said function.

11. An exposure method that forms a predetermined
pattern on each of a plurality of divided areas on a
25 plurality of substrates by sequentially performing
exposure of said plurality of divided areas on said
plurality of substrates, said exposure method comprising:
detecting a piece of position information of each

divided area on an n'th substrate of said plurality of substrates by using a position detection method according to claim 5, said n being larger than or equal to two; and performing, after having moved each of said divided
5 areas to an exposure reference position based on said detection results, exposure on said divided area.

12. A device manufacturing method including a lithography process, wherein in said lithography process,
10 exposure is performed by using an exposure method according to claim 11.

13. A position detection method that detects a piece of position information to be used to align each of
15 a plurality of divided areas on a substrate with respect to a predetermined point, wherein, for a second or later (n'th) substrate of said plurality of substrates, so as to detect a piece of position information of each of said plurality of divided areas of a plurality of substrates,
20 are used a linear component of a piece of position information of said divided area obtained by performing a statistic computation using measured position information in accord with position deviations of at least three specific divided areas relative to said predetermined
25 point specified in design-position information, and a nonlinear component of a piece of position information of said divided area on at least one of substrates earlier than said n'th substrate, said measured position

information being measured by detecting a plurality of marks on said n'th substrate.

14. A position detection method according to claim
5 13, wherein said nonlinear component of a piece of position information of each of said divided areas is calculated based on a single complement function optimized based on indices of regularity and degree of a nonlinear distortion, of at least one of substrates
10 earlier than said n'th substrate, that are obtained by, through use of a predetermined evaluation function, evaluating pieces of measured position information of said divided areas on said substrate, and based on a nonlinear component of a piece of position information of
15 said divided area on at least one of substrates earlier than said n'th substrate.

15. A position detection method according to claim
14, wherein said complement function is a function
20 expanded by the Fourier series, and wherein based on results of said evaluation a highest order of said Fourier series expansion is optimized.

16. A position detection method according to claim
25 13, wherein said nonlinear component of said piece of position information of each of said divided areas is calculated based on a difference between a piece of position information of said divided area, which is

calculated by weighting measured position information, which is obtained by detecting a plurality of marks on said at least one of substrates earlier than said n'th substrate, and performing a statistic computation using
5 said weighted information, and a piece of position information of said divided area calculated by performing a statistic computation using measured position information, which is obtained by detecting a plurality of marks on said at least one of substrates earlier than
10 said n'th substrate.

17. An exposure method that forms a predetermined pattern on each of a plurality of divided areas on a plurality of substrates by sequentially performing
15 exposure of said plurality of divided areas on said plurality of substrates, said exposure method comprising:

detecting a piece of position information of each divided area on an n'th substrate of said plurality of substrates by using a position detection method according
20 to claim 13, said n being larger than or equal to two; and

performing, after having moved each of said divided areas to an exposure reference position based on said detection results, exposure on said divided area.

25

18. A device manufacturing method including a lithography process, wherein in said lithography process, exposure is performed by using an exposure method

according to claim 17.

19. A position detection method that detects a piece of position information to be used to align each of a plurality of divided areas on a substrate with respect to a predetermined point, said method comprising:

grouping, for a second or later (n'th) substrate of a plurality of substrates, a plurality of divided areas on said substrate into blocks beforehand based on indices representing regularity and degree of a nonlinear distortion of at least one of substrates earlier than said n'th substrate so as to detect a piece of position information of each of said plurality of divided areas of said plurality of substrates, said indices being obtained by evaluating, through use of a predetermined evaluation function, measured position information in accord with position deviations, relative to said predetermined point, of said divided areas on said at least one of substrates earlier than said n'th substrate; and

determining said pieces of position information of all divided areas belonging to each of said blocks by using measured position information in accord with position deviations, relative to said predetermined point, of a second number of divided areas, said second number being smaller than a first number, which represents a total number of divided areas belonging to each of said blocks.

20. An exposure method that forms a predetermined pattern on each of a plurality of divided areas on a plurality of substrates by sequentially performing exposure of said plurality of divided areas on said plurality of substrates, said exposure method comprising:

5 detecting a piece of position information of each divided area on an n'th substrate of said plurality of substrates by using a position detection method according to claim 19, said n being larger than or equal to two;
10 and

performing, after having moved each of said divided areas to an exposure reference position based on said detection results, exposure on said divided area.

15 21. A device manufacturing method including a lithography process, wherein in said lithography process, exposure is performed by using an exposure method according to claim 20.

20 22. A position detection method that detects a piece of position information to be used to align each of a plurality of divided areas on a substrate with respect to a predetermined point, said method comprising:

determining a weight parameter for weighting, by
25 using a function that is used to obtain correlation, concerning at least direction, between a first vector representing a position deviation amount of a given divided area on said substrate and second vectors each

representing a position deviation amount of a divided area of a plurality of divide areas around said given divided area, said position deviation amount of said first vector being relative to a predetermined reference position, said position deviation amounts of said second vectors being relative to said predetermined reference position; and

weighting measured position information, obtained by detecting a plurality of marks on said substrate, by using said weight parameter and calculating said piece of position information by a statistic computation using said weighted, measured position information.

23. An exposure method that forms a predetermined pattern on each of a plurality of divided areas on a plurality of substrates by sequentially performing exposure of said plurality of divided areas on said plurality of substrates, said exposure method comprising:

detecting a piece of position information of each divided area on an n 'th substrate of said plurality of substrates by using a position detection method according to claim 22, said n being larger than or equal to two; and

performing, after having moved each of said divided areas to an exposure reference position based on said detection results, exposure on said divided area.

24. A device manufacturing method including a

lithography process, wherein in said lithography process, exposure is performed by using an exposure method according to claim 23.

5 25. An exposure method that forms a predetermined pattern on each of a plurality of divided areas on a substrate by sequentially performing exposure of said plurality of divided areas on said substrate, said exposure method comprising:

10 making, for each of at least two conditions concerning said substrate, beforehand at least a correction map based on measurement results of a plurality of marks on a specific substrate, said correction map being composed of pieces of correction
15 information used to correct nonlinear components of position deviation amounts, relative to respective reference positions, of a plurality of divided areas on said substrate;

 selecting a correction map corresponding to a
20 designated condition before exposure; and

 calculating pieces of position information used to align each divided area with respect to a predetermined point, through use of a statistic computation, based on measured position information obtained by detecting a
25 plurality of marks provided corresponding to each of a plurality of specific divided areas on said substrate and performing, after having moved said substrate based on said pieces of position information and said selected

correction map, exposure on said divided areas.

26. An exposure method according to claim 25,
wherein said at least two conditions include at
5 least two process conditions through which substrates
have been,

wherein upon said map making, said correction map
is made for each of a plurality of specific substrates
that have been through different processes, and

10 wherein upon said selection, a correction map is
selected that corresponds to a substrate subject to
exposure.

27. An exposure method according to claim 25,
15 wherein said at least two conditions include at
least two conditions concerning selection of said
plurality of specific divided areas of which said marks
are detected to obtain said measured position information,

wherein upon said map making, position deviation
20 amounts relative to respective reference positions of a
plurality of divided areas on said specific substrate are
obtained by detecting marks provided corresponding to
each of said plurality of divided areas on said specific
substrate, wherein pieces of position information of said
25 divided areas are calculated through use of a statistic
computation using measured position information obtained
by detecting marks corresponding to a plurality of
specific divided areas that are corresponding to said

condition and are on said specific substrate, for each of
said conditions concerning selection of said specific
divided areas, and wherein a correction map is made based
on said pieces of position information and said position
5 deviation amounts of said divided areas, said correction
map being composed of pieces of correction information
used to correct nonlinear components of position
deviation amounts, relative to respective reference
positions, of said divided areas; and

10 wherein upon said selection, a correction map is
selected that corresponds to designated selection
information of specific divided areas.

28. An exposure method according to claim 25,
15 wherein said specific substrate is a reference
substrate.

29. An exposure method according to claim 25,
 wherein upon said exposure, if divided areas on
20 said substrate subject to exposure include an imperfect
area which is in periphery of said substrate and of which
a piece of correction information is not contained in
said correction map, a piece of correction information of
said imperfect area is calculated by a weighted-average
25 computation based on a Gauss distribution and using
pieces of correction information, contained in said
correction map, of a plurality of divided areas adjacent
to said imperfect area.

30. A device manufacturing method including a lithography process, wherein in said lithography process, exposure is performed by using an exposure method
5 according to claim 25.

31. An exposure method that forms a predetermined pattern on each of a plurality of divided areas on a substrate by sequentially performing exposure of said
10 plurality of divided areas on said substrate, said exposure method comprising:

measuring pieces of position information of mark areas each corresponding to a respective mark by detecting a plurality of marks on a reference substrate;
15 obtaining, by a statistic computation using said pieces of measured position information, pieces of calculated position information of said mark areas, each having a linear component of position deviation amount thereof, relative to a design value of a respective mark
20 area, corrected;

making a first correction map including pieces of correction information used to correct nonlinear components of position deviation amounts of said mark areas, based on said pieces of measured position
25 information and said pieces of calculated position information, each of said position deviation amounts being relative to a design value of a respective mark area;

converting, before exposure, said first correction map to a second correction map, based on information concerning a designated arrangement of divided areas, said second correction map including pieces of correction
5 information used to correct nonlinear components of position deviation amounts of said divided areas, each of said position deviation amounts being relative to a reference position of a respective divided area of said divided areas; and

10 calculating pieces of position information, used to align each divided area with respect to a predetermined point, through use of a statistic computation based on measured position information obtained by detecting a plurality of marks on said substrate and performing,
15 while moving said substrate based on said pieces of position information and said second correction map, exposure on said divided areas.

32. An exposure method according to claim 31,
20 wherein in said map conversion, a piece of correction information of a reference position on each of said divided areas is calculated by a weighted-average computation assuming a Gauss distribution, based on pieces of correction information of a plurality of mark
25 areas adjacent to said reference position.

33. A position detection method according to claim 31, wherein said map conversion is realized by, for a

reference position on each of said divided areas,
performing a complement computation based on pieces of
correction information of said mark areas and a single
complement function optimized based on results of
5 evaluating, through use of a predetermined evaluation
function, regularity and degree of a nonlinear distortion
of a region of a substrate.

34. A device manufacturing method including a
10 lithography process, wherein in said lithography process,
exposure is performed by using an exposure method
according to claim 31.

35. An exposure method that forms a predetermined
15 pattern on each of a plurality of divided areas on a
plurality of substrates by using a plurality of exposure
apparatuses including at least one exposure apparatus
capable of correcting distortion of projected image and
sequentially performing exposure of said divided areas on
20 said substrates, said exposure method comprising:

an analysis step of analyzing overlay error
information, measured beforehand, of at least one
specific substrate that has been through the same process
as said substrates;

25 a first judgment step of judging, based on said
analysis results, whether or not errors between divided
areas on said specific substrate are predominant, said
errors between divided areas being caused by position

deviation amounts having different translation components from each other;

a second judgment step of, when in said first judgment step it has been judged that said errors between
5 divided areas are predominant, judging whether or not said errors between divided areas have a nonlinear component;

a first exposure step of, when in said second judgment step it has been judged that said errors between
10 divided areas have no nonlinear component, with using an arbitrary exposure apparatus, calculating pieces of position information used to align each divided area with respect to a predetermined point, by a statistic computation using measured position information obtained
15 by detecting marks corresponding to each of a plurality of specific divided areas on each of said plurality of substrates and sequentially performing exposure on said plurality of divided areas of each of said plurality of substrates so as to form said pattern on each divided
20 area, while moving said substrate based on said pieces of position information;

a second exposure step of, when in said second judgment step it has been judged that said errors between divided areas have a nonlinear component, with using an
25 exposure apparatus that can perform exposure on substrates correcting said errors between divided areas, sequentially performing exposure on said plurality of divided areas of each of said plurality of substrates so

as to form said pattern on each divided area; and

5 a third exposure step of, when in said first judgment step it has been judged that said errors between divided areas are not predominant, selecting an exposure apparatus capable of correcting distortion of said projected image and, with using said selected exposure apparatus, sequentially performing exposure on said plurality of divided areas of each of said plurality of substrates so as to form said pattern on each divided
10 area.

36. An exposure method according to claim 35, further comprising:

15 a selection step of, when in said second judgment step it has been judged that said errors between divided areas have a nonlinear component, selecting and instructing an exposure apparatus that can perform exposure on substrates correcting said errors between divided areas to perform exposure;

20 a third judgment step of judging how large differences of overlay errors between a plurality of lots are, said lots including a lot to which a substrate subject to exposure belongs; and

25 wherein in said second exposure step, when upon sequentially performing exposure on said plurality of divided areas of each of said plurality of substrates so as to form said pattern on each divided area, in said third judgment step it has been judged that differences

of overlay errors between lots are large, said exposure apparatus, for each of a predetermined number of first and following substrates of said lot, calculates pieces of position information used to align each divided area with respect to a predetermined point, by a statistic computation using measured position information obtained by detecting a plurality of marks on said substrate, calculates nonlinear components of position deviation amounts, relative to respective predetermined reference positions, of said divided areas by using said measured position information and a predetermined function, and moves said substrate based on said pieces of position information calculated and said nonlinear components, and for each of the other substrates, calculates pieces of position information used to align each divided area with respect to a predetermined point, by a statistic computation using measured position information obtained by detecting a plurality of marks on said substrate, and moves said substrate based on said pieces of position information calculated and said nonlinear components calculated, and

wherein when in said third judgment step it has been judged that differences of overlay errors between lots are not large, said exposure apparatus, for each substrate of said lot, calculates pieces of position information used to align each divided area with respect to a predetermined point, by a statistic computation using measured position information obtained by detecting

a plurality of marks on said substrate, and moves said substrate based on said pieces of position information calculated and a correction map that is made beforehand and composed of pieces of correction information used to
5 correct nonlinear components of position deviation amounts, relative to respective reference positions, of a plurality of divided areas on a substrate.

37. A device manufacturing method including a
10 lithography process, wherein in said lithography process, exposure is performed by using an exposure method according to claim 35.

38. An exposure apparatus that forms a
15 predetermined pattern on each divided area on a plurality of substrates by performing exposure on said substrates, said exposure apparatus comprising:

a judgment unit of judging how large differences of overlay errors between a plurality of lots are, said lots
20 including a lot to which a substrate subject to exposure belongs;

a first controller that, when said judgment unit judges that differences of overlay errors between lots are large, upon exposure for each of a predetermined
25 number of first and following substrates of said lot, calculates pieces of position information used to align each divided area with respect to a predetermined point, by a statistic computation using measured position

information obtained by detecting a plurality of marks on said substrate, calculates nonlinear components of position deviation amounts, relative to respective predetermined reference positions, of said divided areas
5 by using said measured position information and a predetermined function, and moves said substrate based on said pieces of position information calculated and said nonlinear components, and upon exposure for each of the other substrates in said lot, calculates pieces of
10 position information used to align each divided area with respect to a predetermined point, by a statistic computation using measured position information obtained by detecting a plurality of marks on said substrate, and moves said substrate based on said pieces of position
15 information calculated and said nonlinear components calculated; and

a second controller that, when said judgment unit judges that differences of overlay errors between lots are not large, upon exposure for each substrate of said
20 lot, calculates pieces of position information used to align each divided area with respect to a predetermined point, by a statistic computation using measured position information obtained by detecting a plurality of marks on said substrate, and moves said substrate based on said
25 pieces of position information calculated and a correction map that is made beforehand and composed of pieces of correction information used to correct nonlinear components of position deviation amounts,

relative to respective reference positions, of a plurality of divided areas on a substrate.

39. An exposure method that forms a predetermined
5 pattern on each of a plurality of divided areas on a substrate by performing exposure on said divided area, said exposure method comprising:

selecting a first alignment mode, when, based on overlay error information of an exposure apparatus used
10 in exposure of said substrate, errors between divided areas on said substrate are predominant, and a second alignment mode different from said first alignment mode, when errors between divided areas on said substrate are not predominant; and

15 determining respective pieces of position information of said divided areas based on pieces of position information obtained by detecting a plurality of marks on said substrate using said selected alignment mode.